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Abstract

This paper explores the effect of neighborhood attributes on housing prices. We first analyze the price that subjects are willing to pay for these attributes and second, how this neighborhood variables are distributed within the city. Using both the demand and the spatial supply of these variables we evaluate the spatial evolution of housing prices. Results indicate that neighborhood amenities influence the distribution of housing prices within the city.
KEYWORDS: Location Choice, Externalities, Housing Prices, Centrifugal and Centripetal Forces
JEL CLASS.:R15, R21, D12

1 Introduction

Why families decide to move out to any determined suburb within the city? which dwelling attributes are householders searching for: housing characteristics, neighborhood amenities or both? Moreover, if consumers care about neighborhood attributes, do all suburbs provide these amenities? This set of questions are crucial for urban economists, planners and, obviously, politicians.

Regarding the literature, since the pioneering work of Alonso (1964) an increasing number of researchers have been interested in the causes of residential location choice. The monocentric model (Alonso, 1964; Mills 1967; Muth 1969; Solow 1972; Fujita 1989) introduces the commuting cost as the main variable that shapes housing prices. The model supposes that all the working and commercial locations are placed at the Central Business District (CBD hereafter), so commuting costs are an increasing function of distance. This unique CBD determines the spatially symmetric urban structure and the circular growth of the city; hence the distance to the CBD is the only explanatory variable of housing prices, being price decreasing with distance. Therefore, the population density function has a negative exponential slope, known as the Muth-Mills gradient. Fujita proves that the localization equilibrium is optimal, satisfying the Paretian conditions, in the absence of externalities.

However, if consumers care about the neighborhood quality, the hypothesis of absence of externalities is not trivial. Anas (1978) or Arnott (1987), consider the dynamics of deterioration of the CBD. As the result of its agglomeration (congestion) problems, high income individuals leave the CBD. This process is named “filtering”. Generally speaking, richer families move out from the CBD looking for better environmental quality in the surrounding areas (see Ellis 1967; Yamada 1972 and Alperovich 1980 for seminal studies about the effect of environmental quality on location choice).

Interestingly, not only environmental attributes affect consumer demand but also a number of papers (Kain and Quigley 1975; Papageorgiou 1976; Freeman 1979; Dubin and Cheing 1990; Sivitanidou 1996) had showed the relevance of neighborhood quality variables —such as average income, race, services or schools— as determinant of housing demand[1].

In recent years, some theoretical papers use dynamic models to explain population mobility whitin and/or between cities. In this way, Fujita and Thisse (1996), Fujita, Krugman, and Mori (1999) and Case and Mayer (1996) introduce centrifugal (repulsion) and centripetal (attraction) forces to explain why agglomeration increases (or decreases) the population density in different parts of the city.

In this paper, we want to introduce a new way to study housing prices spatial distribution. If population density is sensitive to centrifugal and centripetal forces then, housing markets should also reflect these forces. To this end we will use the same database as Brañas-Garza et al. (2002). Thus, this paper must be considered as a a follow-up of the previous one.

What does this paper add? In contrast to the previous one we do not only estimate the housing demand equation but we also study how attributes demanded by the citizens are spatially distributed within the city (*supply*). Using both estimations we can study, within each part of the city, how the housing price will vary as the consequence not only of demand but also supply of attributes, that is, the equilibrium of agglomeration-dispersion forces.

The paper is structured as follows. Section 2 explains objectives, methods and dataset. Section 3 illustratable some figures from the city of Córdoba. Section 4 analyzes results. The fifth section revises them and section 6 concludes.

2 Objectives, Methodology and Data

2.1 Objectives

This paper is crucially based on two assumption: (i) Housing demand includes neighborhood attributes and (ii) Supply of these attributes is not homogeneous within the whole city.

The former assumptions will be tested along this paper. Then, we will analyze how these neighborhood amenities[2] are distributed within the city and how sensitive is the housing demand to those attributes (hereafter *external attributes*). With both estimations at hand we will be able to study how housing prices reflect both variables.

First, we will study how consumers value these external variables. To this end, we will estimate a classical housing demand equation. In this equation we will not only consider the basic housing features or *internal attributes* (size and other specific characteristics) but also we include three external attributes: average income, average building age and average level of pollution. These estimated values reflect the amount of money subjects are willing to pay for getting an additional unit of the attribute at hand (that is, its shadow price).

Second, we analyze how external attributes are distributed across the city. To conduct this spatial study we divide the whole sample (the city of Cordoba) in four subsamples (*NE, NW, SE* and *SW*). Within each sub-sample we study the spatial distribution of each external variables; hence, we will check how the external variable at hand varies with distance to the CBD.

Finally, using the former analysis (spatial distribution) and the shadow price for each external variable we will observe how the housing price reflects the demand and supply for these attributes.

2.2 Methodology

Hedonic price methodology is used to estimate the value —shadow price— that subjects give to any external attribute (see Lancaster 1966; Chow 1967, Griliches 1971 and Rosen 1974 as classical references; for a modern perspective see Ekeland et al. 2004). The essence of the hedonic method is the analysis of a good (for example, dwellings) as a bundle of desirable characteristics. For a good, Z, we suppose that the price depends on some characteristics or attributes z_i and other unknown variables u:

$$P_z = \Omega(z_1, z_2, ..., z_n, u), \tag{1}$$

If we estimate the model $\hat{P} = \hat{\alpha} + \sum \hat{\beta}_i z_i + e$ we can derive the marginal price of each attribute, $\partial\hat{\Omega}/\partial z_i$. The implicit price equation is derived by using multivariate regression (Ordinary Least Squares), so the marginal price the individuals are willing to pay for each characteristic (Berndt, 1991) is the estimated coefficient. This estimator is named the shadow price of the any housing attribute, $\hat{P}(z_i)$.

To study the spatial distribution or the intensity-distance gradient of each external attribute we use a simple method. Let us define $dCBD$ as the linear distance of any k-point within the city to the CBD. We estimate $z_i(k)$=$f(dCBD)$, that is, how the amount of this attribute increases/decreases with distance to CBD. We estimate this equation using OLS for each external variable and for each subsample. We also consider how the dwelling size varies with distance in order to eliminate its possible spatial effects. Note that if housing size increases/decreases with distance, then, it will affect prices too. Although it is possible to find a certain degree of spatial autocorrelation and heteroskedasticity in cross–section data, the introduction of distance variables in the model specification can minimize this problem[3].

2.3 Data

In this paper we use the same database as in Brañas-Garza et al. (2002), This data set is built on surveys from real-estate agents in Córdoba and the opinions of municipal experts from the Town Hall, the Department of Urban Planning and the Traffic Department. Surveys were made at three real-estate agencies located in the CBD, the southwest, and the northeast. These were carried out from January to April of 1996. The sample consists of 1,023 dwellings distributed across the 26 neighborhoods of the city. Each record reflects the spatial position of the dwelling and its specific characteristics: surface, price, condition, orientation, etc.

The total sample was divided into four groups to facilitate the analysis of the different sub-markets: Northwest (*NW*) 263 apartments, Northeast (*NE*) 155 apartments, Southwest (*SW*) 408 apartments, and Southeast (*SE*) 416 apartments. When we estimate each group, we also include all the CBD apartments (73). The variables used are the following:

- Internal variables or Housing attributes:
  - Selling price of the dwelling in Spanish pesetas of 1996, (p)
  - Housing size in square meters ($size$)
  - Distance to the CBD, that is, the distance in meters of the neighborhood[4] to the city center ($dCBD$)
  - Specific distance from the apartment to the neighborhood center (sd).
- External variables o Neighborhood attributes:
  - Building age index (age). This index values the average age of the buildings located within each suburb. This gives a higher value to the newest houses, and a lower one to the oldest apartments. We obtained this index through the age of the houses included in the database.

– Average income index ($income$) is obtained from the Urban Department of the Town Hall. This variable ranks neighborhoods from level 1 (very low) to level 5 (very high).

– Congestion index ($congest$) includes congestion and pollution caused by traffic and depends on traffic level and infrastructure endowment. This index was created by the Traffic Department of Córdoba.

3 The city of Córdoba

Córdoba is a medium-size city located in Southern Spain. It has a privileged geographical position, because it is located at the center of Andalusia, 140 km. from Sevilla, 170 from Málaga and 160 from Granada. Its communications with the rest of Spain are excellent. It is connected to Madrid (400 km.) by high speed train and by highway. Regarding the city itself, we need to point out several important factors that influence the spatial distribution of housing price.

(1) The city of Córdoba is located in a valley. It is surrounded in the northwest by the foothills of Sierra Morena, in the southeast by the Guadalquivir River, and in both the northeast and the southwest borders are plains. Given the city extreme climate, especially the hot summers, the temperate northwest is the most desirable place to live.

(2) Until 1992 the city was divided on an east–west axis by the railway line, and connecting routes between both sides were minimal. The railway complex was completely reformed and buried in 1992, unifying the city. The covered areas have been turned into new neighborhoods with modern infrastructures (gardens, parks, etc.) and high land prices.

(3) With regard to the general maintenance of the city, there are two zones that have traditionally been underprivileged. The area on both banks of the river has not been preserved, relegating it to a deprived condition[5]. One could say that the city has turned its back to the river. The other zone of evident neglect up to 1992 borders the train tracks. This explains why prices were very low there, in spite of its proximity to the center. It is interesting to note that prices remained low here not long ago[6].

(4) Córdoba has three CBD (see the black dots in figure 1). The largest is located in the center of the city, generating most of the commercial and employment activity. The second, situated to the northeast, is characterized by high-end commercial activity

and generates substantial employment. Housing prices are understandably high here. The third, much less important, is to the southwest of the city. It has some commercial activity but generates little employment. In particular, it tends to be shifting even more towards the southwest, an area of new development.

[Figure 1 about here.]

The map in figure 1 shows income per capita levels for each zone, that can be summarized as follows: (1) The CBD and the adjoining neighborhoods are high-income areas (rank 5, see previous definition of this variable in section 2.3). This is due not only to its location but also to its general attractiveness as a result of municipal government public works and the restoration of older buildings there. (2) However, a clear east–west asymmetry can be observed. Given a equivalent distance from the city center, the neighborhoods situated to the west have, in general, higher income than those to the east, and almost all the new neighborhoods (see shaded areas in figure 1) are located in the west. It can also be observed that the new neighborhoods are occupied by people with high income (rank 4), due to the high land prices. An exception to this tendency is the area immediately to the west of the railway, which continues to be somewhat marginal[7]. (3) The neighborhoods of the peripheral southwest show very low income per capita (rank 1). This can be explained to a great extend by delinquency and official abandonment.

Regarding population density, the division by the railway and the historical characteristics of the city have been determinant factors: a) The areas right of the tracks and the newly constructed northwest zones have a low population density. Population diminishes as the city climbs into the mountains. b) The historic zone[8] of the city has medium density, which diminishes in relation to its proximity to the river. On the other bank of the river the density is medium. c) On the left side of the tracks, the area between the second CBD and the third CBD (which includes the main CBD) has high density. To the northeast of this zone the density is medium, while there is low-density in the newly constructed neighborhoods at the southwest.

4 Results

The empirical study is divided into three parts. First, we estimate an hedonic equation that let us evaluate the shadow price of both internal and external attributes. Second, the spatial distribution of each neighborhood attribute is analyzed. Third, on the basis of these results, we analyze the centrifugal or centripetal forces that are caused by external attributes.

4.1 Determinants of housing demand

We use a standard hedonic price function (Berndt, 1991) in each sub-sample to evaluate the shadow price, $P(z_i)$, of each attribute. To obtain the implicit prices equation we use multivariate regressions, where the dependent variable is the housing price and the z_i explanatory variables are housing attributes ($size$, $dCBD$ and sd) and neighborhood characteristics ($congest$, age and $income$). Although the internal variables are not determinant for this study, they were introduced in order to establish the best specification.

We use logarithmic specifications, in each case:

$$\hat{P} = e^{\hat{\alpha}} z_1^{\hat{\beta}_1} z_2^{\hat{\beta}_2} z_3^{\hat{\beta}_3} ... z_6^{\hat{\beta}_6} e. \tag{2}$$

Where $\hat{\beta}_i$ is the elasticity of housing prices with respect to the i-attribute, that is $\hat{P}(z_i)$. From now on we will refer to the implicit price as the marginal utility this attribute provides. The estimated coefficients will be analyzed for each zone (using superscripts such NE, NW, etc.) or the whole city (wich be referred as $whole$). We estimate (2) in each zone, as well as in the whole sample, using OLS. Table 1 summarizes the results.

[Table 1 about here.]

As expected, internal attributes are crucial in the demand for housing. The lot surface is a highly explanatory variable for the house price ($U_{size}^{whole} > 0$). Distance to the city core has the negative expected sign ($U_{dCBD}^{whole} < 0$) although its explanatory capability is very low (in all cases $U_{dCBD} = \hat{\beta}_{dCBD}$ is close to -0.05). Finally, the specific distance is also negative ($U_{sd}^{whole} < 0$) and shows a low elasticity, that is, its influence on housing price is reduced.

How are the external attributes valued by the citizens? The following items summarize these estimations:

Congestion level. The estimated value (elasticity) is only not significant for the NE: in the NW and SW it is perceived as negative, that is, its valuation is negative ($U^{SW}_{congest} < U^{NW}_{congest} < 0$), while in the SE the congestion seems to be a desirable attribute ($U^{SE}_{congest} > 0$). The last case can only be explained if the inhabitants of this zone perceive congestion as a result of commercial activity. Commercial activity usually goes in parallel with congestion.

Filtering processes. age was only significant in the SW case; consequently we can assume that people does not assigns much value to this attribute. This situation does not allow us to measure the importance of the forces related to this attribute. In particular, we cannot analyze the effect of filtering processes on housing price. We can find a simple explanation for the case of SW inhabitants: A high percentage of the city's new flats are located in this area, so there is a notable contrast between very old apartments and new ones (see figure 1 in page 18).

Average income. We find some differences in the estimated parameters. In both North zones the value is much higher than in the South and in the total sample. As expected, people in every zone value neighborhood quality positively, but the North residents give it a higher value ($U^{NE,NW}_{income} > U^{SE,SW}_{income} > 0$).

To summarize:

Result 1 *The housing demand includes external attributes. Average income and congestion level are neighborhood amenities which affect significatively housing prices.*

Then, is shown that the first assumption is relevant.

4.2 Asymmetrical Distribution of Attributes

This section studies the spatial distribution of each attribute (along the axes). Lot size is also analyzed to control any spatial effect of internal attributes. Regressions include the $i-th$ attribute as the dependent variable and the distance to the CBD ($dCBD_i$)

as the explanatory one. The same analysis is repeated for each attribute and in each group, using the following functional form[9]:

$$z_i = \mathrm{e}^{\alpha} k^{\beta}, \tag{3}$$

being z_i the attribute and k the distance to CBD. The results are shown in table 2.

[Table 2 about here.]

We will analyze these results in the following paragraphs. Note that the estimation includes both the constant and the elasticity. The former shows the level of the referred attribute in the city center while the elasticity illustrates its change with distance (to the CBD). We will focus on the later. Summarizing:

Dwelling size. The monocentric model supposes that lot size is a linear increasing function of distance to CBD. The first row of table 2 shows the distribution of lot size in relation to distance. In all cases R^2 is really low, so we can assume that there is no relation between size and distance to the CBD. [10]

Result 2 *Housing size does not increase as we move out of the CBD.*

Note that the former result is relevant in the following analysis since external variables are the only significantly related to the distance to the CBD.

Congestion level. The variable $congest$ analyzes this external variable (row 2 in table 2). We observe a variability of nearly 50% in the constant values ($\delta = e^{\hat{\alpha}}$) and differences for the elasticity between areas. The explanation is that there are significant differences in how the congestion gradient interact with the different axes of the city, and these results have a direct relation to population density. If we compare the North with other areas, we see that both δ and $\hat{\beta}$ are significantly different: the congestion level is low and declines rapidly here (remember that the *NW* is the closest part of the city to the mountains). *SW* and *NE* are the opposite cases: they are characterized by very high level of congestion and a slow decline in value. In every case the congestion level falls as the distance to the center increases ($congest_k^{whole} < 0$), so we can find clearly a negative externality in the city center. However the gradient of this externality is not symmetric: $congest_k^{NW} < congest_k^{NE} < congest_k^{SE} < congest_k^{SW} < 0$.

Filtering processes. The deterioration of an area and the houses therein is a clear incentive for people to move out. Significant spatial differences in the age of the houses (row 3 of table 2) are tested to define these incentives. In all cases R^2 is very low and the value of δ is similar, and close to 0.20. None of $\hat{\beta}$ are significant. Then, there is no appreciable variability along the axes regarding the age of the houses, and therefore a city growth model based on circles is not acceptable[11].

Income. This neighborhood attribute declines as distance from the CBD increase, so it is a centripetal force ($income_k^{whole} < 0$). Our estimations (row 4 of table 2) show that different axes have different constants, higher in the *SW*, but lower in the *SE* direction. The exponent of the distance (always negative, that means that there is a clear centripetal externality) is also different. Elasticity in *SW* and *SE* cases is double than in *NW* and *NE* ones ($income_k^{SE} \simeq income_k^{SW} < income_k^{NE} < income_k^{NW} < 0$).[12]

Result 3 *The spatial distribution of congestion and relative income is not homogeneous across the city.*

Then, assumption two is also confirmed.

4.3 The Effect of Centrifugal and Centripetal Forces on Housing Price

In this third section we develop the main point of the paper. We combine the prices that subjects are willing to pay for any attribute and its spatial distribution within the city. Both estimations let us define the forces that shape each part of the city.

To validate our predictions we need the real housing prices spatial evolution. To obtain this value we perform a classical Muth-Mills price/distance analysis (see table 3 below). Note that the spatial evolution of the housing price reflects, precisely, how prices varies across the city, then, this price should be considered as the balance between centripetal and centrifugal forces.[13] Hence, the Muth-Mills gradient illustrates the real direction (centripetal of centrifugal) of the total force.

Table 3 shows the value of this gradient for each part of the city. Recall that commuting cost are always centripetal.

[Table 3 about here.]

Housing prices decline with the distance to the CBD in all the cases, although there are several differences that our methodology could help to explain. In the following items we combine the results shown in table 1 and 2 in order to obtain the net effect of centrifugal and centripetal forces.

***Northeast*:** We found only one significant attribute, $income$, with positive shadow price ($U^{NE}_{income} > 0$) but decreasing with the distance ($income^{NE}_k < 0$), then, it is a centripetal force.

Obviously, our prediction is that price is a decreasing function of the distance. The estimated value confirm it: $P(k) = f(dCBD) = -0.11$.

***Northwest*:** Here we observed two attributes: income ($U^{NW}_{income} > 0$ and $income^{NW}_k < 0$) and congestion ($U^{NW}_{congest} < 0$ and $congest^{NW}_k < 0$). Then, we have one centripetal and one centrifugal forces.

As there are two opposite forces, the resulting force is centripetal, but with a very flat slope ($\hat{\beta} = -0.08$).

***Southwest*:** Again there are two attributes: income appears as centripetal ($U^{SW}_{income} > 0$ and $income^{SW}_k < 0$) and congestion causes crowding-out ($U^{SW}_{congest} < 0$ and $congest^{SW}_k < 0$).

As the centripetal force is more intense, the resulting total force is centripetal with a slope $\hat{\beta} = -0.10$, some way between the NE and NW cases.

***Southeast*:** In this last case we found two attributes: income once more is centripetal ($U^{SE}_{income} > 0$ and $income^{SE}_k < 0$) and congestion is also centripetal ($U^{SE}_{congest} > 0$ and $congest^{SE}_k < 0$).

As both forces are centripetal (attraction to the city center), the gradient ($\hat{\beta} = -0.15$) is higher (in absolute value) than in the other zones. In this area the price falls more rapidly than in the rest of the city.

Result 4 *The real spatial evolution of housing prices validates our estimation of centrifugal and centripetal forces.*

5 Discussion

Most of the results of the previous section have a sensible interpretation if we consider the characteristics of Córdoba.

Northeast: There is a high degree of economic activity in this area, and the second CBD located there is increasingly important. However, it also has a congestion problem because there are few amenities. This problem cannot be easily solved, and this negative externality will probably increase with time. In contrast with other areas, its possibilities for expansion are very limited (it is close to the ring road).

Northwest: It clearly has the best environmental conditions and the highest relative level of income of all the city. The results analyzed above lead us to believe that the northwest will have prices as high as those of the CBD in the future. In this case, prices will not fall with distance. Note that this prediction is sensible if people values neighborhood quality.

Southwest: It should be highlighted that most new neighborhoods are being built in this area. Although these neighborhoods are not developed in our sample period, it is reasonable to believe that eventually they will be very desirable because of environmental amenities like parks and open areas.

Southeast: This is the most deprived zone of the city, where government intervention has been very limited. The degradation of the river area could be a major influence on the zone. However, the local government is now improving and remodeling the river and its banks, which possibly could have a positive effect on the zone in general. Also, new houses have been recently built.

6 Conclusions

The aim of this paper was to contrast the effect of externalities on location choice and its consequences on housing prices. To achieve that we have used a novel method in the estimation of the price gradient determinants similar to the Slutsky decomposition. As we have spatial data on the value of each attribute, it is possible to decompose the price variation as an addition of all the attributes effects following a hedonic model framework.

The results seem to confirm that there is a relationship between amenities, valuation and housing prices. These results can be summarized as follows. First, the externality shadow price depends on the particular features of the area chosen, so there are also asymmetries in the attribute valuation. Second, some of the externalities that affect individual location choice, specially congestion and neighborhood quality, show clear spatial asymmetries. Third, with respect to centrifugal/centripetal forces we have shown that: CBD congestion always acts like a centrifugal force, but its intensity depends upon the particular case. However, neighborhood quality may be centrifugal or centripetal, depending on the source location.

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Notes

[1]See also Brouhle et al. (2003) for a recent paper on public goods provision in a Tiebout model.

[2]We will use the terms Amenities and attributes interchangeably.

[3]We wish to thank J. Suriñach, R. Moreno and E. Vayá at this point.

[4]The location of the main branch of Cajasur (the main local financial institution) is used to define the central point of each neighborhood.

[5]But since the year 2000, the Town Hall have started an ambitious renewal program that is likely to significantly improve this area.

[6]An specific urban plan has been developed for this area since year 2000. This project comprises both public and private uses of the old railway complex (now buried) and generous public investment. As a result this area has changed from a deprived to a very desirable place for living. Now, housing prices are similar to the rest of the city center. However average income of dwellers is still very low.

[7]Like in footnote 6 we should remark that now, in year 2004, the area located close to the old railway system have become highly developed.

[8]The historic area, known as the Jewish quarter, is located in the southeast quadrant of the city, it extends from the main CBD towards the river.

[9]We use this non-lineal specification because of its better adjustment (Suriñach and Martorí, 1997).

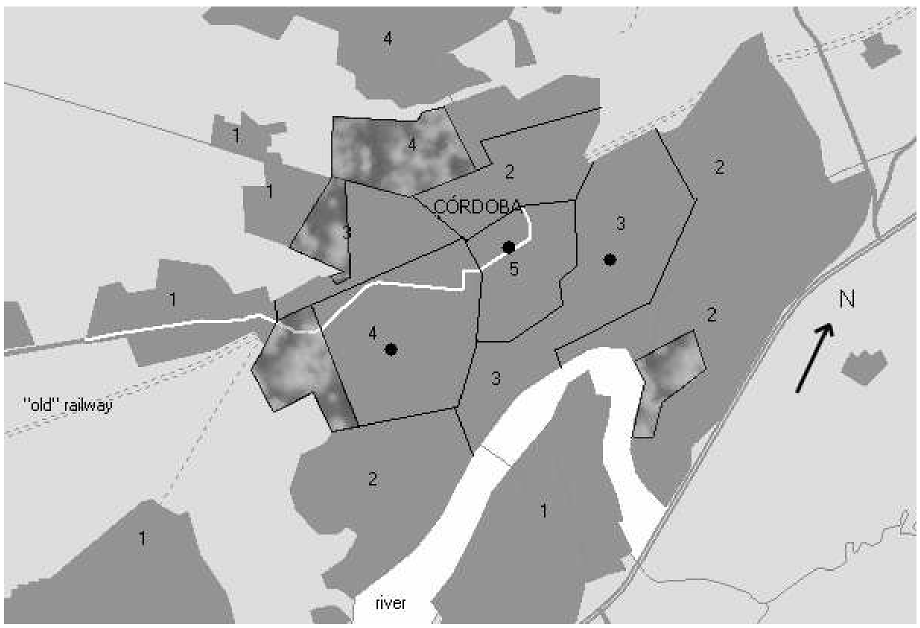
[10]Also, no significant differences in the constant values are found. There are some differences in the elasticity level, however these are always negative. In the SE case the value is double that of the SW and NE, which are quite similar. The NW value is not significant. This means that housing size does not increase as we move out of the CBD. If there is any relation at all it is a inverse one. That is, the largest apartments are located in the city center, and this relationship is not symmetric along the axes.

[11]Although many new houses have recently been built in the West (see figure 1), there are also many new ones in the East. In addition, many of the new neighborhoods are located relatively close to the CBD. Once again we see that the division of the city by the railway line has been determinant in its pattern of growth.

[12]This attribute declines faster in the South than in the North. A possible explanation can be found through the commercial activity: the main and secondary CBDs are located in both North areas. In the South we only find the 3rd CBD but this is still not well-developed; even more, some south areas have externalities caused by deterioration and official abandonment.

[13]Note that we need an additional assumption. We need to impose that commuting costs increase with the distance to the CBD but equally in every point i at the same $dCBD$, that is, in any cardinal direction.

Formally, $T_k^{i)}(dCBD) = T_k(dCBD), \quad \forall i.$



Numbers 1–5 means increasing levels of relative per capita income (1 means very low and 5 very high). The dotted double line is the (old) railway track. Shaded areas are newly developed neighborhoods.

Figure 1: Income per capita of Neighborhoods and New Zones

Table 1: Estimation of shadow prices

	Total Sample	Northeast	Northwest	Southeast	Southwest
interc.	5.30 (51.3)	5.21 (23.2)	5.42 (30.4)	5.55 (37.2)	5.75 (34.5)
size	0.93 (41.8)	0.92 (19.0)	0.88 (23.5)	0.87 (26.8)	0.86 (24.9)
dCDB	-0.06 (-11.7)	-0.05 (-3.2)	-0.06 (-5.4)	-0.07 (-11.9)	-0.06 (-9.8)
sd	-0.03 (-9.4)	-0.02 (-2.6)	-0.03 (-4.9)	-0.03 (-6.5)	-0.03 (-4.7)
congest	—	—	-0.03 (-2.5)	0.02 (4.3)	-0.08 (-2.5)
age	—	—	—	—	-0.01 (-2.2)
income	0.04 (8.4)	0.18 (2.9)	0.17 (3.7)	0.03 (5.5)	0.05 (5.5)
R^2	0.81	0.87	0.88	0.86	0.80
n	1023	155	263	416	408

* between bracket we show the t-student test value.

Table 2: Spatial distribution of attributes

	Northwest		Northeast		Southwest		Southeast	
	δ	$\hat{\beta}$	δ	$\hat{\beta}$	δ	$\hat{\beta}$	δ	$\hat{\beta}$
size	103.54 (131.7)	-0.00 (-0.05)	99.48 (115.7)	-0.03 (-2.4)	102.61 (178.8)	-0.03 (-3.2)	91.83 (182.1)	-0.06 (-7.1)
	R^2=0.00		R^2=0.05		R^2=0.03		R^2=0.13	
congest	2.48 (8.3)	-0.30 (-6.5)	3.28 (59.7)	-0.22 (-110.5)	3.7 (41.7)	-0.13 (-11.8)	2.77 (12.5)	-0.19 (-6.5)
	R^2=0.13		R^2=0.46		R^2=0.25		R^2=0.09	
age	0.23 (-8.9)	-0.01 (-0.2)	0.24 (-7.2)	-0.02 (-0.3)	0.19 (-10.1)	-0.07 (-1.2)	0.21 (-9.2)	-0.01 (-0.3)
	R^2=0.0002		R^2=0.0008		R^2=0.003		R^2=0.0001	
income	2.77 (39.3)	-0.15 (-13.7)	2.58 (40.3)	-0.22 (-24.8)	3.38 (17.1)	-0.32 (-12.4)	2.18 (12.3)	-0.33 (-14.3)
	R^2=0.41		R^2=0.80		R^2=0.27		R^2=0.33	

* between bracket we show the t-student test value.

** note that δ=$e^{\hat{\alpha}}$. The t values are obtained for $\hat{\alpha}$.

Table 3: Estimation of Distance-Price Slope

$y = e^{\hat{\alpha}} k^{\hat{\beta}}$	(being y the housing price and k the distance)				
Southwest		coeff.	st. error	t-stat.	prob.
	intercept	9.61	0.02	366.5	0.00
R^2=0.23	*logDCBD*	-0.1	0.009	-11.7	0.00
Northwest		coeff.	st. error	t-stat.	prob.
	intercept	9.58	0.03	271.7	0.00
R^2=0.11	*logDCBD*	-0.08	0.014	-5.8	0.00
Northeast		coeff.	st. error	t-stat.	prob.
	intercept	9.57	0.03	289.5	0.00
R^2=0.36	*logDCBD*	-0.11	0.01	-9.3	0.00
Southeast		coeff.	st. error	t-stat.	prob.
	intercept	9.47	0.02	384.9	0.00
R^2=0.39	*logDCBD*	-0.15	0.009	-16.5	0.00